# Synergy Science Knowledge Organiser
8 Radiation and Risk

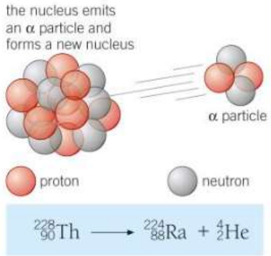
## Radioactive particles

- The nuclear radiation emitted may be:
- Alpha particle (α) – this consists of two neutrons and two protons; it is identical to the nucleus of a helium atom

Mass number = 4 $\quad {}^{4}_{2}\mathrm{He} \quad \alpha$

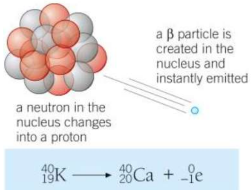
Atomic number = 2

least penetrating $\qquad$ most ionising



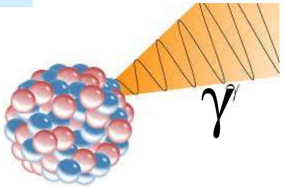

- a beta particle (β) – a high-speed electron ejected from the nucleus as a neutron turns into a proton

Mass number = 0 $\quad {}^{0}_{-1}\mathrm{e} \quad \beta$




- a gamma ray (γ) – electromagnetic radiation from the nucleus

most penetrating $\qquad$ least ionising




## Measuring radioactive decay

- Radioactive decay measured in <u>Becquerel (Bq)</u>
- A Geiger counter is used to detect radioactivity by counting the number of decays each second (count-rate)
- Geiger-Muller tube connects to an electric counter which clicks each time a particle of radiation enters the Geiger tube

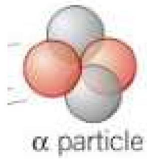

## Radioactive decay

- The emission of the different types of ionising radiation may cause a change in the mass and/or the charge of the nucleus.

Mass number = number of protons + number of neutrons

Atomic number = number of protons

- Alpha decay causes the atomic number to decrease by two units and the mass number by four units:




Mass number $\quad 219 - 215 = 4$

$$^{219}_{86}\mathrm{Ra} \longrightarrow {}^{215}_{84}\mathrm{Po} + {}^{4}_{2}\mathrm{He}$$

Atomic number $\quad 86 - 84 = 2$

- There is no change in mass number during beta decay but the atomic number increases by one unit.
- there is 1 more proton and 1 less neutron

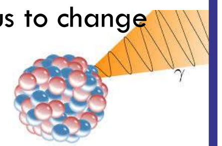
β

Mass number $\quad 14 - 14 = 0$

$$^{14}_{6}\mathrm{C} \longrightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$$

Atomic number $\quad 6 + 1 = 7$

- A gamma ray is electromagnetic radiation from the nucleus of an atom
- Gamma rays are uncharged and have no mass
- Gamma rays do not cause the mass or the charge of the nucleus to change



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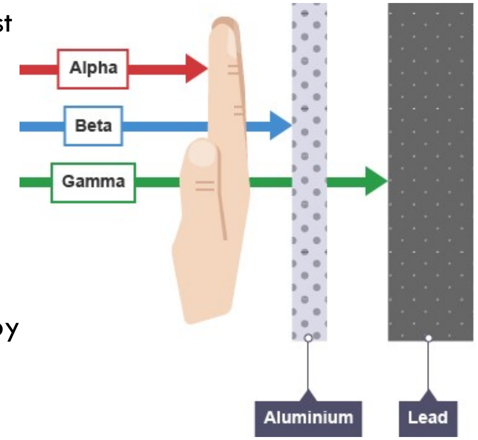
## Penetrative properties

- Alpha particles are absorbed by just a few millimetres of air or by a thin sheet of paper.
- Beta particles can pass through air and paper but are completely absorbed by a sheet of metal just a few millimetres thick.
- Gamma rays pass through most materials easily but are absorbed by a thick sheet of lead or by several metres of concrete.



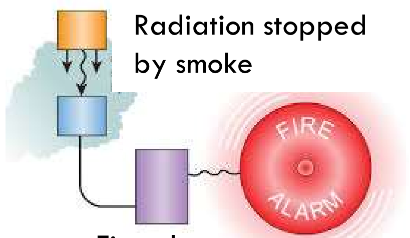

## Contamination and Irradiation

- Irradiation is the process of exposing an object to radiation from an outside source. Irradiation can be reduced by screening the source or moving the object away from it. The irradiated object does not become radioactive.
- Radioactive contamination is the unwanted presence of a source of radiation inside, or on the surface of, other materials. It is often difficult to remove the contaminating source so that it continues to add to the radiation dose for as long as it emits radiation.

| Irradiation | Contamination |
|---|---|
| Occurs when an object is exposed to a source of radiation outside the object. | Occurs if the radioactive source is on or in the object. |
| Doesn't cause the object to become radioactive. | A contaminated object will be radioactive for as long as the source is on or in it. |
| Can be blocked with suitable shielding or moving away. | Once an object is contaminated, the radiation cannot be blocked from it. |
| Stops as soon as the source is removed. | It can be very difficult to remove all of the contamination. |

## Uses

α

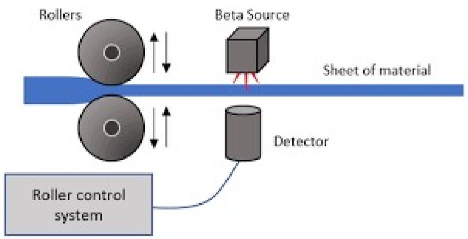


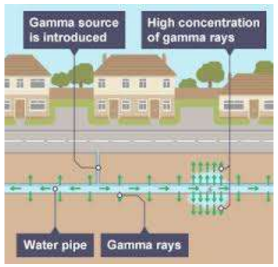

Radiation stopped by smoke

α : Fire alarm

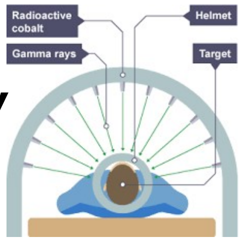
β: Chemical tracers for medical imaging
Thickness of paper or plastic in industry

β



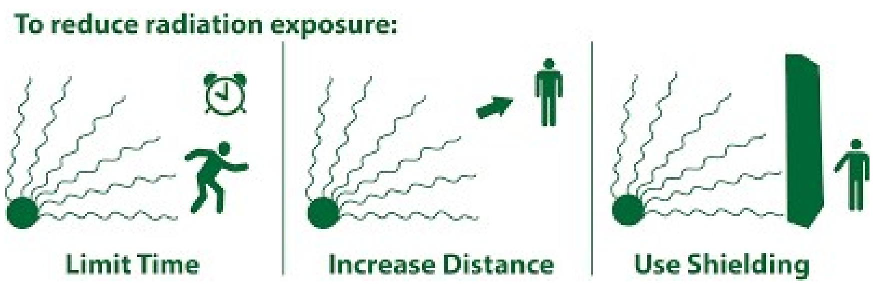

γ




γ: Detecting leaks
Sterilising medical equipment
Treatment of cancer

## Safety

(i) protective clothing
(ii) using tongs
(iii) short exposure time
(iv) lead-lined containers for radioactive materials → hazard symbol displayed




- Studies on the effects of radiation of humans need to be shared and published so the findings can be checked by peer reviews and scrutinised

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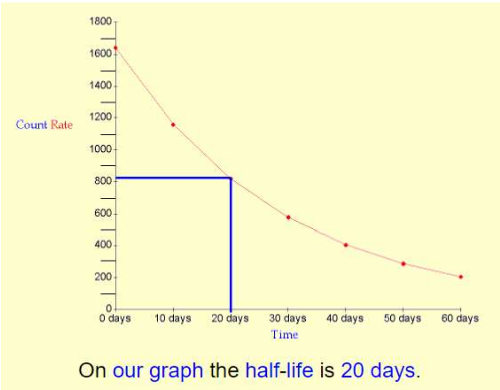
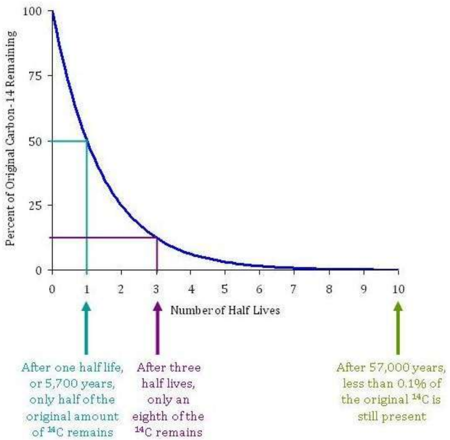
## Half-life

- Radioactive decay is random, so it is not possible to predict which individual nucleus will decay next. But with a large enough number of nuclei it is possible to predict how many will decay in a certain amount of time.
- The half-life of a radioactive isotope is the average time it takes for the number of nuclei of the isotope in a sample to halve, or the average time it takes for the count rate from a sample containing a radioactive isotope to fall to half its initial level.
- Count rate is the number of decays recorded each second by a detector (such as a Geiger–Müller tube).




## Risks of Ionising radiation

- The hazardous effects of ultraviolet (UV) waves, X-rays, alpha, beta and gamma rays depend on the type of radiation and the size of the dose.
- Radiation dose (in Sieverts) is a measure of the risk of harm resulting from an exposure of the body to the radiation. 1 Sievert (Sv) = 1000 millisieverts (mSv).
- Ultraviolet waves, X-rays, alpha, beta and gamma rays are all examples of ionising radiation. They can turn atoms into ions and break up molecules.
- Ionising radiations can change DNA, causing mutation of genes that may lead to cancer. High-energy gamma rays can be used to destroy cancer cells.
- The hazard from contamination is due to the decay of the contaminating atoms

| | | |
|---|---|---|
| Eating a banana that contains radioactive potassium | 0.000000098 Sv | 0.000098 mSv |
| Exposure for cabin crew on airliners (per year) | 0.0016 Sv | 1.6 mSv |
| 6 months on the International Space station | 0.08 Sv | 80 mSv |
| Highest dose to a worker during Fukushima disaster | 0.67 Sv | 670 mSv |
| Typical fatal dose | 10 Sv | 10,000 mSv |

## Cancer

- Tumours form when cells start growing and dividing in an uncontrolled way. Some tumours are benign; they stay in the same place and stop growing before they get too large.
- Cancer is caused by malignant tumours that are able to invade neighbouring tissues and spread to different parts of the body in the blood so that more tumours start to grow in other parts of the body.

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## Radioactive particles

- Task: Draw the symbols for

  Alpha Beta Gamma

- Task: What are the particles made of?

  Alpha Beta Gamma

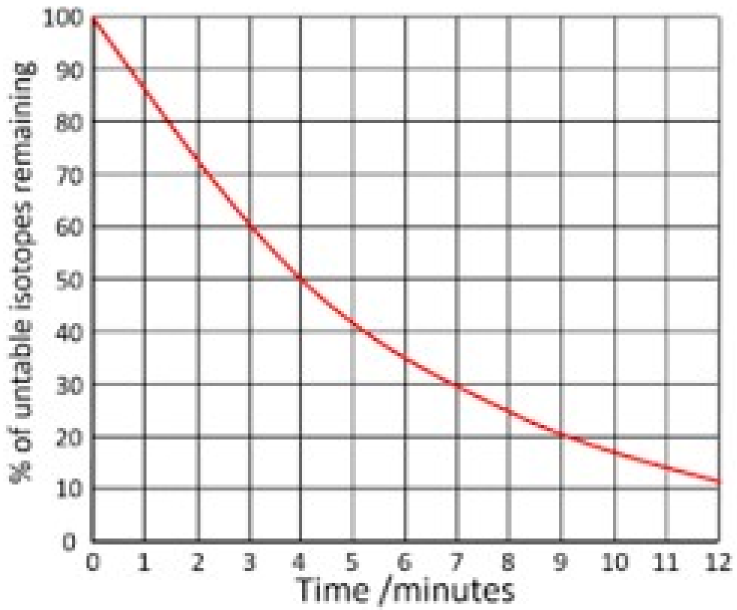
## Uses

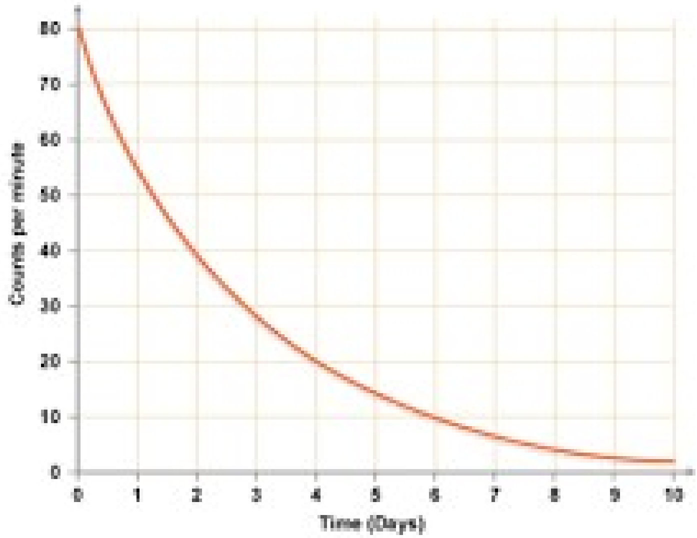
- Task: Complete the table to show the uses of each type of radiation

| Type of radiation | Use |
|---|---|
| | Thickness of paper or plastic in industry |
| | Fire alarm |
| | Detecting leaks |
| | Chemical tracers for medical imaging |
| | Sterilising medical equipment |
| | Treatment of cancer |

## Half-life

- Task: Calculate the half-life of these isotopes




**Highlight the keywords: Nucleus, Geiger counter, electron, electromagnetic, helium, neutron, proton, Alpha, beta, gamma, ionising, decay, half-life, activity, becquerels, Contamination, Irradiation, malignant, tumour**